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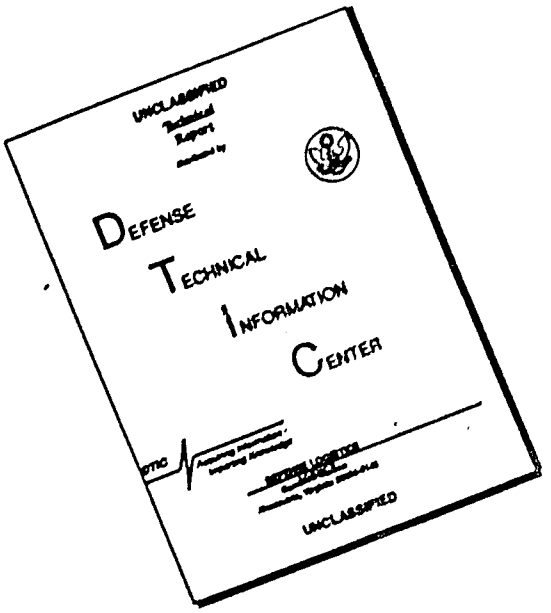

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AMRL-TDR-63-57

CORRELATION BETWEEN VISUAL AND AUDITORY VIGILANCE PERFORMANCE

LOUIS T. POPE, Ph.D.
DON F. McKECHNIE

TECHNICAL DOCUMENTARY REPORT No. AMRL-TDR-63-57

JULY 1963

BEHAVIORAL SCIENCES LABORATORY
6570th AEROSPACE MEDICAL RESEARCH LABORATORIES
AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

Project No. 7184, Task No. 718406

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FOREWORD

This report was prepared by the Maintenance Design Branch, Human Engineering Division, Behavioral Sciences Laboratory, 6570th Aerospace Medical Research Laboratories of the Aerospace Medical Division. The investigation was conducted under Project 7184, "Human Performance in Advanced Systems," Task 718406, "The Development of Human Engineering Maintainability Design Criteria," with Dr. Louis T. Pope and Mr. Don F. McKechnie as project scientists.

ABSTRACT

This study investigated the relationship between individual performance on a visual vigilance task and an auditory vigilance task. Each of 40 male college subjects participated in two 35-minute test trials, one visual and one auditory. In each 35-minute trial five randomly spaced vigilance signals were presented. Various indices of correlation computed from the data obtained in this study show no relationship between auditory and visual vigilance performance.

The percentage of signals detected is probably affected by sensory acuity factors; however, the data of this study did not provide a test of this hypothesis. Other studies should be conducted, comparing the decrement in detection efficiency rather than the percentage of total signals detected. This suggested measure should be less sensitive to sensory acuity components of vigilance than the overall percentage detection measure used in this study.

PUBLICATION REVIEW

This technical documentary report has been reviewed and is approved.

Walter F. Grether

WALTER F. GRETHER
Technical Director
Behavioral Sciences Laboratory

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CORRELATION BETWEEN VISUAL AND AUDITORY VIGILANCE PERFORMANCE

by

Louis T. Pope
Don F. McKechnie

INTRODUCTION

In the past few years, increasing interest has been shown in human monitoring behavior. In the Armed Forces and in industry there are many monitoring tasks to be performed, such as detection of infrequent targets on a radar scope or detection of malfunction indications on a control board. These are tasks usually requiring little physical work but demanding constant attention to detect small, infrequent changes in visual or auditory stimuli. Because of the severe demands for sustained attention in these monitoring tasks, they have come to be referred to as vigilance tasks.

Much research has been done on the variables affecting vigilance performance. Most persons performing vigilance tasks over long periods of time have shown a decrement in detection efficiency, i.e., a decrease in the percent of signals detected. One goal of vigilance research is to find ways of reducing this decrement.

Data from several research studies (refs. 1, 2, 4, 5, and 6) have indicated that extreme individual differences exist in vigilance performance. Many subjects consistently show no decrement in performance, while the performance of other subjects deteriorates quite rapidly. Because of the potential importance of individual differences in the selection and training of personnel for monitoring tasks, Buckner et al. (ref. 3) investigated the effect of this factor in vigilance performance. Their results demonstrated the reliability of individual differences in vigilance performance both within watches and from one watch to the next.

In the same study the investigators found only a low correlation (+.24) between individual performance on a visual and on an auditory vigilance task, thus suggesting that performance on one mode is essentially independent of performance on the other. From a theoretical standpoint, the low intermodality relationship between visual and auditory vigilance makes suspect the assumption that a central attention factor is the primary determinant of detection efficiency—an assumption that has been implicit in most of the vigilance literature to date. Because of the importance of this finding, the following study was undertaken.

METHOD

Subjects

Forty volunteer male undergraduate university students participated in the experiment. Each was paid for his services. The subjects were selected on the basis of their ability to detect at least 65% of the 20 signals presented in visual and auditory pretests.*

The Vigilance Tasks

Both visual and auditory vigilance tasks were used. The visual task required detection of a low intensity orange-colored spot of light, 3/8 inch in diameter, which appeared within a 1-inch unlighted square of frosted glass mounted on the face of a cathode ray (CR) oscilloscope.

The auditory vigilance signal consisted of a low intensity (approximately 55 decibel) 1,350 cycle per second (cps) tone presented through the subject's earphones. This vigilance tone was presented against a 500-cps background tone of approximately 90-decibel intensity.

The Equipment

A Webcor stereophonic tape recorder was used to present programmed signals for both visual and auditory trials. The 500-cycle background tone and the 1350-cycle, 3/10-second auditory pulses were both recorded on the same tape. During visual vigilance trials the 1350-cycle pulses triggered a Hunter electronic timer. The timer keyed a light circuit to present the 3/10-second light signal.

The test booth was 5 feet by 6 feet and was 6 feet in height. It was painted black inside and was sealed to exclude outside light. Ventilation was furnished by a ceiling fan, which was run throughout all trials. Light was furnished in the booth by two 40-watt bulbs hidden from direct view of the subject.

A more complete description of the equipment may be obtained by referring to an earlier study by Pope (ref. 7).

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*The intensity of these signals had been previously determined to give a detection probability of 90% (ref. 7) for the average alerted subject.

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Procedure

Each subject participated in two test sessions, one with a simple visual vigilance task and the other with an auditory vigilance task. Twenty of the subjects were given the visual task first and the remaining twenty performed the auditory task first. Order of presentation was randomly determined. Since prior experience with this task (ref. 7) had shown that virtually all the decrement in performance occurred within the first 35 minutes of watch, a watch length of 35 minutes was used in this study. During the 35-minute watch, 5 signals were presented. The signals were programmed to occur at 2, 12, 20, 28, and 32 minutes of elapsed time. To control practice and order effects, the second experimental session for each subject was scheduled one week after the first session and the order of presentation of the auditory and visual tasks was counterbalanced.

The subjects were given instructions for performing their tasks and the nature of the signals was demonstrated to them. No information was given about the number of signals to be presented. The order of events for each session was as follows:

(1) Two-minute practice period.

(2) Five-minute test for subject selection.

(3) Two-minute practice period.

(4) Thirty-five-minute vigilance trial.

RESULTS AND DISCUSSION

The signals missed by each subject during each of the two 35-minute runs served as the dependent measure in this study. A signal was considered missed if there was no subject response within 5 seconds after presentation. Table I shows the percentage of subjects detecting each of the five signals presented for both the visual vigilance and auditory vigilance tasks. These curves approximate the vigilance decrement curves obtained by other investigators. The unexpectedly high percentage of detection for signal 5 may be due partially to the short test period; however, some end-spurt activity is found by many investigators.

The visual and auditory detection scores of the 40 subjects were used to construct the contingency table shown in figure 1. Examination of figure 1 reveals that little difference exists between the score distributions of the two groups. Computation of a contingency coefficient (C) using all 40 score combinations yielded a C of zero (.0007). A Pearson r and a Spearman rank correlation coefficient were also computed, using the visual and auditory detection scores of the 40 subjects and the coefficient obtained in each case was -.11. These correlation indices are all far from significant and would seem to indicate that, in the population represented by the tested group, little or no relationship exists between performance on visual and auditory vigilance tasks of the type used in this study.

TABLE 1

COMPARISON OF SCORES ON VISUAL AND AUDITORY VIGILANCE TRIALS, N = 40*

Signals Missed		VISUAL		
		0 - 2	3 - 5	Totals
AUDITORY	0 - 2	8 8 16	5 4 9	13 12 25
	3 - 5	5 5 10	2 3 5	7 8 15
	Totals	13 13 26	7 7 14	20+ 20‡ 40

* The number on the left side of each cell represents the number of subjects within the cell who performed the auditory vigilance task prior to performing the visual task, and the numbers at the top of the cell represent the number of subjects within the cell who performed the visual task prior to the auditory task. Totals for both groups are shown in the bottom of the cells.

+ Visual First

‡ Auditory First

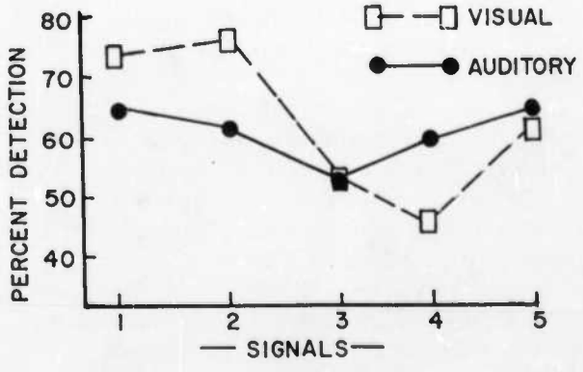

Figure 1

Percentage of Signals Detected for Each of Five Signal Presentations

Each point on each curve represents one signal for each of 40 subjects.

The lack of correlation between auditory and visual vigilance obtained in this study, when considered jointly with the low positive (+.24) correlation obtained by Buckner, et al., leads the present authors to support the position that little or no relationship exists between auditory and visual vigilance performance as defined in these studies. Buckner, et al., suggest that there are two elements of performance to be considered in vigilance: overall performance level and performance decrement within the test period. Overall performance level may be closely related to initial ability to see or hear the signal (sensory acuity) although performance decrement within the test period may relate almost entirely to some central attention factor. Thus, in comparing performance on an auditory vigilance task with visual vigilance performance, we may be to a large extent comparing auditory and visual acuity. In other words, when we compare scores based on the total signals detected, we may be measuring the attention that the subject gives to the signal area plus the strong influence of the subject's ability to see or hear the presented signal. We may be observing both a central and a peripheral phenomenon. Probably a more meaningful comparison could be made between individual performance decrements within a trial or trials. The authors would expect to find a significant positive correlation between decrement scores or curves in the different sensory modes. In the present study, five vigilance signals for each subject in each mode were considered an inadequate sample of subject performance to yield a valid measure of individual vigilance decrement within the trials.

The existence of a significant relationship between individual performance on visual and auditory vigilance tasks has not been demonstrated in this study and additional research exploring possible reasons for this apparent lack of relationship is needed. We believe a study comparing individual decrements within the vigilance trials, rather than the overall percentage of signals detected for individuals, is a necessary step toward fuller understanding of the vigilance phenomenon.

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